

Amendments to the Specification

Please delete the heading "Specification" on page 1, line 2.

Please add the following heading after the title of the invention on page 1, line 2:

Background of the Invention

Please replace the paragraphs beginning on page 1, line 9 through page 2, line 12, which start with "With the widespread use of " with the following rewritten paragraphs:

With the widespread use of fuel injection devices called injectors in recent years, the control of the fuel injection timing and the fuel injection amount, namely, the air-fuel ratio has become easy, which makes it possible to improve engine output and fuel consumption and to clean exhaust gas. As to the fuel injection timing, it is common that the phase state of a camshaft, the state of an intake valve, to be exact, is detected, and, based on the detected result, fuel is injected. However, a cam sensor for detecting the phase state of a camshaft, which is expensive and increases the size of a cylinder head, is difficult to employ in motorcycles or the like, in particular. To solve this problem, an engine control device adapted to detect the phase state of a crankshaft and an intake air pressure and, based on those, to detect the stroke state of a cylinder is ~~proposed in JP-A H10-227252~~ conventionally known. ~~With this prior art~~ Thus, it is possible to detect the stroke state of a cylinder without detecting the phase of a camshaft, so that it is possible to control the fuel injection timing based on the stroke state.

The stroke state can be detected based on variations in the engine rotational speed during one cycle. The engine rotational speed is highest in the expansion (explosion) stroke, followed by the exhaust stroke, intake stroke and compression stroke in that order. Thus, the stroke state can be detected from variations in the engine rotational speed and the phase of a crankshaft. ~~An~~ A conventional engine control device ~~disclosed in JP-A 2000-337206~~ is adapted to select the stroke detection based on variations in intake air pressure or stroke detection based on variations in the engine rotational speed according to the operating condition of the engine and detect a stroke by the selected method.

With the conventional engine control device ~~disclosed in JP-A 2000-337206~~, however, it is difficult to select an appropriate stroke detection method over the entire operating conditions

of the engine and, in some cases, neither of the stroke detection methods is appropriate. Thus, the reliability of the detected stroke is low.

The present invention has been made to solve the above problem and it is an ~~object~~ advantage of the present invention to provide an engine control device which can perform stroke detection with high reliability.

Please replace the heading on page 2, line 13 with the following rewritten heading:

~~Disclosure of~~ Summary of the Invention

Please replace the paragraphs beginning on page 2, line 14 through line 34, which start with "In order to solve the foregoing" with the following rewritten paragraph:

In order to solve the foregoing problem, the engine control device of the present invention ~~comprises:~~ includes a crankshaft phase detecting means for detecting device that detects the phase of a crankshaft, a intake air pressure detecting means for detecting device that detects the intake air pressure in an intake pipe of an engine; and a stroke detecting means for detecting device that detects a stroke of the engine based on at least the phase of the crankshaft detected by the crankshaft phase detecting ~~means,~~ device. The engine control device also includes an engine control means for controlling device that controls the operating condition of the engine based on the stroke of the engine detected by the stroke detecting ~~means~~ device and the intake air pressure detected by the intake air pressure detecting ~~means~~ device, and an engine rotational speed detecting means for detecting device that detects the engine rotational speed; ~~wherein the~~ The stroke detecting means device detects a stroke based on variations in the intake air pressure detected by the intake air pressure detecting ~~means~~ device and detects a stroke based on variations in the engine rotational speed detected by the engine rotational speed detecting ~~means~~ device, and completes stroke detection when the detected strokes coincide with each other.

Please replace the paragraph beginning on page 3, line 4 through line 5, which starts with "FIG. 2 is an explanatory" with the following rewritten paragraph:

FIG. 2(a) and 2(b) ~~is are~~ are an explanatory views illustrating a principle of outputting crank pulses in the engine in FIG. 1;

Please replace the heading on page 3, line 31, with the following rewritten heading:

~~Best Mode of for Carrying Out~~ Detailed Description of the Invention

Please replace the paragraphs beginning on page 4, line 1 through page 7, line 34, which start with "FIG. 1 is a schematic diagram" with the following rewritten paragraphs:

FIG. 1 is a schematic diagram illustrating an example of an engine for a motorcycle or the like and a control device therefor. Designated as the reference numeral 1 is a relatively small displacement, single-cylinder, four-cycle engine. The engine 1 has a cylinder body 2, a crankshaft 3, a piston 4, a combustion chamber 5, an intake pipe 6, an intake valve 7, an exhaust pipe 8, an exhaust valve 9, a spark plug 10 and an ignition coil 11. In the intake pipe 6, a throttle valve 12 which is opened and closed in accordance with throttle opening is provided and an injector 13 as a fuel injection device is disposed downstream of the throttle valve 12. The injector 13 is connected to a filter 18, a fuel pump 17 and a pressure control valve 16 which are housed in a fuel tank 19.

The operating condition of the engine 1 is controlled by an engine control unit 15. As ~~means for~~ For performing control input into the engine control unit 15, namely ~~means for~~ detecting the operating condition of the engine 1, there are provided a crank angle sensor 20 for detecting the rotational angle, namely phase, of the crankshaft 3, a cooling water temperature sensor 21 for detecting the temperature of the cylinder body 2 or cooling water, namely the temperature of the engine body, an exhaust air-fuel ratio sensor 22 for detecting the air-fuel ratio in the exhaust pipe 8, an intake air pressure sensor 24 for detecting the pressure of intake air in the intake pipe 6, and an intake temperature sensor 25 for detecting the temperature in the intake pipe 6, namely the temperature of intake air. The engine control unit 15 receives detecting signals from the sensors and outputs control signals to the fuel pump 17, the pressure control valve 16, the injector 13 and the ignition coil 11.

Here, the principle of the crank angle signals which are output from the crank angle sensor 20 will be described. In this embodiment, a plurality of teeth 23 are formed on an outer periphery of the crankshaft 3 at generally equal intervals as shown in FIG. 2a. The crank angle sensor 20, such as a magnetic sensor, detects the approach of the teeth 23, and the resulting current is electrically processed and output as pulse signals. The circumferential pitch between two adjacent teeth 23 is 30° in the phase (rotational angle) of the crankshaft 3, and the

circumferential width of each of the teeth 23 is 10° in the phase (rotational angle) of the crankshaft 3. There is a part where two adjacent teeth are arranged not at the above pitch but at a pitch which is twice as large as the others. It is a special part where there is no tooth where there should be one as shown by phantom lines in FIG. 2a. This part corresponds to an irregular interval. This part may be hereinafter also referred to as the "tooth missing part".

Thus, when the crankshaft 3 is rotating at a constant speed, the train of pulse signals corresponding to the teeth 23 appears as shown in FIG. 2b. FIG. 2a shows the state where the cylinder is at compression top dead center (the state is the same as when the cylinder is at exhaust top dead center). The pulse signal output immediately before the cylinder reaches compression top dead center is numbered as "0", and the following pulse signals are numbered as "1", "2", "3" and "4". The tooth missing part, which comes after the tooth 23 corresponding to the pulse signal "4", is counted as one tooth as if there were one there, and the pulse signal corresponding to the next tooth 23 is numbered as "6". When this process is continued, the tooth missing part comes again after a pulse signal "16". The tooth missing part is again counted as one tooth as above, and the pulse signal corresponding to the next tooth 23 is numbered as "18". When the crankshaft 3 rotates twice, the four strokes of one cycle complete, so that the pulse signal which appears after the pulse signal "23" is numbered as "0" again. In principle, the cylinder reaches compression top dead center immediately after the pulse signals numbered as "0" appear. The thus detected pulse signal train or each pulse signal is defined as a "crank pulse". When the stroke detection is performed based on the crank pulse as described later, crank timing can be detected. The teeth 23 may be formed on an outer periphery of a member which is rotated in synchronization with the crankshaft 3.

The engine control unit 15 is constituted of a microcomputer (not shown) and so on. FIG. 3 is a block diagram illustrating an embodiment of the engine control operation performed by the microcomputer in the engine control unit 15. The engine control operation is performed by an engine rotational speed calculating part 26 for calculating the engine rotational speed based on a crank angle signal, a crank timing detecting part 27 for detecting crank timing information, namely the stroke state, based on the crank angle signal, an intake air pressure signal and the engine rotational speed calculated in the engine rotational speed calculating part 26, and a stroke detection permitting part 29 which reads the engine rotational speed calculated in the engine rotational speed calculating part 26 and outputs stroke detection permitting information to the

crank timing detecting part 27 and which reads and outputs stroke detection information provided by the crank timing detecting part 27; ~~an~~

An in-cylinder air mass calculating part 28 is provided for calculating the air mass in the cylinder (amount of intake air) based on the crank timing information detected by the crank timing detecting part 27 together with an intake air temperature signal, a cooling water temperature (engine temperature) signal, the intake air pressure signal and the engine rotational speed calculated in the engine rotational speed calculating part 26; ~~a~~ A target air-fuel ratio calculating part 33 for calculating a target air-fuel ratio based on the engine rotational speed calculated in the engine rotational speed calculating part 26 and the intake air pressure signal;

~~a~~ A fuel injection amount calculating part 34 for calculating a fuel injection amount and fuel injection timing based on the target air-fuel ratio calculated in the target air-fuel ratio calculating part 33, the intake air pressure signal, the air mass in the cylinder calculated in the in-cylinder air mass calculating part 28, the stroke detection information output from the stroke detection permitting part 29, and the cooling water temperature signal; is also provided. ~~an~~ An injection pulse output part 30 for outputting injection pulses corresponding to the fuel injection amount and the fuel injection timing calculated in the fuel injection amount calculating part 34 to the injector 13 based on the crank timing information detected by the crank timing detecting part 27; is provided.

~~an~~ An ignition timing calculating part 31 is provided for calculating ignition timing from the engine rotational speed calculated in the engine rotational speed calculating part 26, the target air-fuel ratio set by the target air-fuel ratio calculating part 33, and the stroke detection information output from the stroke detection permitting part 29; ~~and an~~ An ignition pulse output part 32 is provided for outputting ignition pulses corresponding to the ignition timing set by the ignition timing calculating part 31 to the ignition coil 11 based on the crank timing information detected by the crank timing detecting part 27.

The engine rotational speed calculating part 26 calculates the rotational speed of the crankshaft as an output shaft of the engine as the engine rotational speed based on the rate of change of the crank angle signal with time. More specifically, the engine rotational speed calculating part 26 calculates an instantaneous value of the engine rotational speed by dividing the phase between two adjacent teeth 23 by the time needed to detect corresponding crank pulses and an average engine rotational speed that is an average movement distance of the teeth 23.

The stroke detection permitting part 29 outputs stroke detection permitting information to the crank timing detecting part 27 according to the operation shown in FIG. 4. As described before, it takes at least two rotations of the crankshaft 3 to detect a stroke based on crank pulses and it is necessary for the crank pulses including the tooth missing part to be stable during that time. In a relatively small displacement, a single-cylinder engine as in this embodiment, however, the rotating state is unstable during cranking as it is called at the time of starting. Thus, the stroke detection is permitted after judgment of the rotating state of the engine is made according to the operation shown in FIG. 4.

The operation shown in FIG. 4 is performed using an input of a crank pulse as a trigger. Although there is provided no the step for communication in the flowchart, the information obtained through the operation is accordingly stored in a memory in an overwriting manner and information and programs necessary for the operation are read out from the memory as needed.

Please replace the paragraph beginning on page 8, line 17 through line 24, which starts with "The process is then goes" with the following rewritten paragraph:

The process is then goes to the step S15, in which it is judged whether the average engine rotational speed read in the step S14 is not lower than a predetermined prescribed rotational speed for detecting a complete explosion corresponding to a rotational speed at a complete explosion. If the average engine rotational speed is not lower than the rotational speed for detecting a complete explosion, the process goes to the step S16. Otherwise, the process goes to the step S17.

Please replace the paragraphs beginning on page 8, line 27 through page 9, line 1, which start with "In the step S17," with the following rewritten paragraphs:

In the step S17, it is judged whether there was an output of an initial explosion detection in the step S13 or whether there was an output of a complete explosion detection in the step S16. If there was an output of an initial explosion detection or complete explosion detection, the process goes to the step S18. Otherwise, the process goes to the step S19.

In the step S18, information that a stroke detection is permitted is output. Then, the process returns to a main program.

In the step S19, information that a stroke detection is not permitted is output. Then, the process returns to the main program.

Please replace the paragraphs beginning on page 9, line 7 through page 10, line 20, which start with "The crank timing detecting part" with the following rewritten paragraphs:

The crank timing detecting part 27, ~~which has a constitution similar to the stroke judging device disclosed in JP-A-H10-227252,~~ detects a stroke based on variations in intake air pressure and a stroke based on variations in the engine rotational speed and outputs information on the stroke state as crank timing information. Here, the principle of detection of a stroke based on variations in the intake air pressure will be described. In a four-stroke engine, the crankshaft and the camshaft are constantly rotated with a prescribed phase difference, so that when crank pulses are read as shown in FIG. 5, the fourth crank pulse after the tooth missing part, namely the crank pulse "9" or "21", represents either an exhaust stroke or a compression stroke. As is well known, during an exhaust stroke, the exhaust valve is opened and the intake valve is closed, so that the intake air pressure is high. However, in an early stage of a compression stroke, the intake air pressure is low because the intake valve is still open or because of the previous intake stroke even if the intake valve is closed. Thus, the crank pulse "21" output when the intake air pressure is low indicates that the cylinder is on a compression stroke, and the cylinder reaches compression top dead center immediately after the crank pulse "0" is obtained. More specifically, when the difference between the intake air pressures at two bottom dead centers is a prescribed negative value or smaller, the cylinder is at bottom dead center after an intake stroke and when the difference is a prescribed positive value or greater, the cylinder is at bottom dead center before an exhaust stroke. When a stroke can be detected as above, it is possible to detect the present stroke state in further detail by interpolating the intervals between the strokes with the rotational speed of the crankshaft.

The engine rotational speed is highest in the expansion stroke in the four strokes: intake, compression, expansion (explosion) and exhaust, followed, in this order, by exhaust stroke, intake stroke and compression stroke. By combining the variations in the engine rotational speed and the phase of the crankshaft represented by crank pulses, a stroke can be detected as in the case with the stroke detection based on variations in the intake air pressure. More specifically, when the difference between the engine rotational speeds at top and bottom dead centers is a

prescribed negative value or smaller, the cylinder is at bottom dead center after an intake stroke, and when the difference is a prescribed positive value or greater, the cylinder is at bottom dead center before an exhaust stroke.

Thus, the crank timing detecting part 27 performs an operation shown in FIG. 6 for setting the operation mode and detecting a stroke. The operation shown in FIG. 6 is performed using an input of a crank pulse, for example, as a trigger. Although there is provided no ~~the~~ step for communication in the flowchart, the information obtained through the operation is accordingly stored in the memory in an overwriting manner and information and programs necessary for the operation are read out from the memory as needed.

Please replace the paragraphs beginning on page 12, line 5 through line 22, which start with “In the step S117” with the following rewritten paragraphs:

In the step S117, it is judged whether the engine rotational speed difference ΔN calculated in the step S115 is not smaller than a predetermined positive threshold value ΔN_{EX} of the engine rotational speed difference before an exhaust stroke. If the engine rotational speed difference ΔN is not smaller than the threshold value ΔN_{EX} of the engine rotational speed difference before the exhaust stroke, the process goes to the step S118. Otherwise, the process goes to the step S119.

In the step S119, it is judged whether the engine rotational speed difference ΔN calculated in the step S115 is not greater than a predetermined negative threshold value ΔN_{IN} of the engine rotational speed difference after the intake stroke. If the engine rotational speed difference ΔN is not greater than the threshold value ΔN_{IN} of the engine rotational speed difference after the intake stroke, the process goes to the step S118. Otherwise, the process goes to the step S120.

In the step S118, stroke detection based on the engine rotational speed difference ΔN is performed as described before. Then, the process goes to the step S121.

Please replace the paragraphs beginning on page 12, line 28 through page 13, line 20, which start with “In the step S122” with the following rewritten paragraphs:

In the step S122, a flag F_N for the stroke detection based on the engine rotational speed difference is set to “1”. Then, the process goes to the step S124.

In the step S123, the flag F_N for stroke detection based on the engine rotational speed difference is set to “2”. Then, the process goes to the step S124.

In the step S124, a counter CNT_N for the stroke detection based on the engine rotational speed difference is incremented. Then, the process goes to the step S125.

In the step 125, it is judged whether the flag F_N for stroke detection based on the engine rotational speed difference has been set to “1” and whether the counter CNT_N for stroke detection based on the engine rotational speed difference is at a value which is not smaller than a predetermined prescribed value CNT_{N0} . If the flag F_N for the stroke detection based on the engine rotational speed difference has been set to “1” and the counter CNT_N for the stroke detection based on the engine rotational speed difference is at a value which is not smaller than the prescribed value CNT_{N0} , the process goes to the step S126. Otherwise, the process goes to the step S116.

In the step S126, the detection of a temporary stroke based on an engine rotational speed difference is regarded as having been completed. Then, the process goes to the step S116.

In the step S120, the flag F_N for the stroke detection based on the engine rotational speed difference is reset to “0”. Then, the process goes to the step S127.

In the step S127, the counter CNT_N for the stroke detection based on the engine rotational speed difference is cleared to “0”. Then, the process goes to the step S116.

Please replace the paragraphs beginning on page 13, line 30 through page 14, line 11, which start with “In the step S130” with the following rewritten paragraphs:

In the step S130, it is judged whether the intake air pressure difference ΔP calculated in the step S128 is not smaller than a predetermined positive threshold value ΔP_{EX} of the intake air pressure difference before the exhaust stroke. If the intake air pressure difference ΔP is not smaller than the threshold value ΔP_{EX} of the intake air pressure difference before the exhaust stroke, the process goes to the step S131. Otherwise, the process goes to the step S132.

In the step S132, it is judged whether the intake air pressure difference ΔP calculated in the step S128 is not greater than a predetermined negative threshold value ΔP_{IN} of the intake air pressure difference after the intake stroke. If the intake air pressure difference ΔP is not greater than the threshold value ΔP_{IN} of the intake air pressure difference after the intake stroke, the process goes to the step S131. Otherwise, the process goes to the step S133.

In the step S131, the stroke detection based on the intake air pressure difference ΔP is performed as described before. Then, the process goes to the step S134.

Please replace the paragraphs beginning on page 14, line 17 through page 15 line 28, which start with "In the step S122" with the following rewritten paragraphs:

In the step S135, a flag F_P for the stroke detection based on the intake air pressure difference is set to "1". Then, the process goes to the step S137.

In the step S136, the flag F_P for the stroke detection based on the intake air pressure difference is set to "2". Then, the process goes to the step S137.

In the step S137, a counter CNT_P for the stroke detection based on the intake air pressure difference is incremented. Then, the process goes to the step S138.

In the step S138, it is judged whether the flag F_P for the stroke detection based on the intake air pressure difference has been set to "1" and whether the counter CNT_P for the stroke detection based on the intake air pressure difference is at a value which is not smaller than a predetermined prescribed value CNT_{P0} . If the flag F_P for the stroke detection based on the intake air pressure difference has been set to "1" and the counter CNT_P for the stroke detection based on the intake air pressure difference is at a value which is not smaller than the prescribed value CNT_{P0} , the process goes to the step S139. Otherwise, the process goes to the step S129.

In the step S139, the detection of a temporary stroke based on an intake air pressure difference is regarded as having been completed. Then, the process goes to the step S129.

In the step S133, the flag F_P for the stroke detection based on the intake air pressure difference is reset to "0". Then, the process goes to the step S140.

In the step S140, the counter CNT_P for the stroke detection based on the intake air pressure difference is cleared to "0". Then, the process goes to the step S129.

In the step S129, it is judged whether the counter CNT_N for the stroke detection based on the engine rotational speed difference is at a value which is not lower than the prescribed value CNT_{N0} or the counter CNT_P for the stroke detection based on the intake air pressure difference is at a value which is not lower than the prescribed value CNT_{P0} . If either is the case, the process goes to the step S141. Otherwise, the process returns to the main program.

In the step S141, it is judged whether the flag F_N for the stroke detection based on the engine rotational speed difference has been set to “1” and whether the flag F_P for the stroke detection based on the intake air pressure difference has been set to “1”. ~~Both~~ When both the flags have been set to “1”, the process goes to the step S142. Otherwise, the process goes to the step S143.

In the step S143, it is judged whether the flag F_N for the stroke detection based on the engine rotational speed difference has been set to “2” and whether the flag F_P for the stroke detection based on the intake air pressure difference has been set to “2”. ~~Both~~ When both the flags have been set to “2”, the process goes to the step S144. Otherwise, the process goes to the step S145.

Please replace the paragraphs beginning on page 16, line 12 through page 20, line 2, which start with “In the step S148” with the following rewritten paragraphs:

In the step S148, a prescribed fail safe process is performed. Then, the program is ended. Examples of the fuel safe process include lowering the engine torque gradually by decreasing the frequency of ignition gradually, shifting the ignition in the cylinder to the lag side gradually, or closing the throttle quickly at first and then slowly for an indication of abnormality.

According to the operation, at the start of the engine or the like, the operation mode is set to “1” when a prescribed number or more of crank pulses are detected within a prescribed period of time, and set to “2” when the tooth missing part is detected. Then, when the tooth missing part is detected twice in succession and the stroke detection permitting part 29 detects an initial or a complete explosion and permits stroke detection, the operation mode is set to “3”. Then, as described before, it is judged whether the difference ΔN between the engine rotational speeds at top and bottom dead centers is not smaller than the threshold value ΔN_{EX} of the engine rotational

speed difference before the exhaust stroke or not greater than the threshold value ΔN_{IN} of the engine rotational speed difference after the intake stroke to perform the stroke detection based on an engine rotational speed difference. Simultaneously, it is judged whether the difference ΔP between the intake air pressures at two bottom dead centers is not smaller than the threshold value ΔP_{EX} of the intake air pressure difference before the exhaust stroke or not greater than the threshold value ΔP_{IN} of the intake air pressure difference after the intake stroke to perform stroke detection based on an intake air pressure difference. Then, either of the stroke detections is repeated a prescribed number CNT_{NO} or CNT_{PO} of times. Then, when the detected stroke coincides with the temporary stroke, namely, when the stroke detection flag F_N or F_P is set to "1", the temporary detection is completed.

Moreover, the stroke detection based on an engine rotational speed difference ΔN is repeated at least a prescribed value CNT_{NO} of times or the stroke detection based on an intake air pressure difference ΔP is repeated at least a prescribed value CNT_{PO} of times. Then, when the temporary stroke coincides with the detected stroke, namely the flag F_N for the stroke detection based on the engine rotational speed difference is set to "1" as a result of the stroke detection based on an engine rotational speed difference ΔN and when the temporary stroke coincides with the detected stroke, namely the flag F_P for the stroke detection based on the intake air pressure difference is set to "1" as a result of the stroke detection based on an intake air pressure difference ΔP , the temporary stroke is determined as the true stroke as it is. Thereby, the stroke detection is completed. Then, the operation mode is set to "4". When the temporary stroke differs from the detected stroke, namely the flag F_N for stroke detection based on the engine rotational speed difference is set to "2" as a result of the stroke detection based on an engine rotational speed difference ΔN and when the temporary stroke differs from the detected stroke, namely the flag F_P for stroke detection based on the intake air pressure difference is set "2" as a result of the stroke detection based on an intake air pressure difference ΔP , the temporary stroke is shifted by a phase of 360° and determined as the true stroke. Thereby, the stroke detection is completed. Then, the operation mode is set to "4". In shifting the phase of the stroke, a crank pulse is renumbered.

The in-cylinder air mass calculating part 28 has a three-dimensional map as shown in FIG. 7 for use in calculating the air mass in the cylinder based on an intake air pressure signal and an engine rotational speed calculated in the engine rotational speed calculating part 26. The three-dimensional map for use in calculating the air mass in the cylinder can be obtained only by measuring the air mass in the cylinder while changing the intake air pressure with the engine rotated at a prescribed rotational speed. The measurement can be conducted with a relatively simple experiment, so that the map can be organized with ease. The map could be organized with an advanced engine simulation system. The air mass in the cylinder, which is changed with the engine temperature, may be corrected with the cooling water temperature (engine temperature) signal.

The target air-fuel ratio calculating part 33 has a three-dimensional map as shown in FIG. 8 for use in calculating a target air-fuel ratio based on an intake air pressure signal and an engine rotational speed calculated in the engine rotational speed calculating part 26. The three-dimensional map can be organized on paper to some extent. In general, the air-fuel ratio is correlated with the torque. When the air-fuel ratio is low, namely, when the amount of fuel is large and the amount of air is small, the torque increases but the efficiency decreases. Whereas, when the air-fuel ratio is high, namely, when the amount of fuel is small and the amount of air is large, the torque decreases but the efficiency increases. The state where the air-fuel ratio is low is called “rich” and the state where the air-fuel ratio is high is called “lean”. The leanest state is one often referred to as “stoichiometry”, where the ideal air-fuel ratio at which complete combustion of gasoline takes place, namely, an air-fuel ratio of 14.7 is attained.

The engine rotational speed indicates the operating condition of the engine. In general, the air-fuel ratio is increased when the engine rotational speed is high and decreased when the engine rotational speed is low. This is to enhance torque responsiveness in the low rotational speed range and to enhance rotation responsiveness in the high rotational speed range. The intake air pressure indicates the engine load such as the throttle opening. In general, when the engine load is large, namely, when the throttle opening is large and the intake air pressure is high, the air-fuel ratio is decreased and when the engine load is small, namely, when the throttle opening is small and the intake air pressure is low, the air-fuel ratio is increased. This is because the torque is important when the engine load is large and efficiency is important when the engine load is small.

As above, the target air-fuel ratio has a physical meaning easy to understand and thus can be set to some extent in accordance with the required engine output characteristics. It is needless to say that the air-fuel ratio may be tuned in accordance with the output characteristics of an actual engine.

The target air-fuel ratio calculating part 33 has a transition correction part 29 for detecting transitions, more specifically, the accelerating state and decelerating state of the engine based on an intake air pressure signal and correcting the target air-fuel ratio in response thereto. For example, as shown in FIG. 9, the change of the intake air pressure is also a result of an operation of the throttle, so that an increase of the intake air pressure indicates that the throttle is opened to accelerate the vehicle, namely, the engine is accelerating. When such an accelerating state is detected, the target air-fuel ratio is set to the rich side temporarily and then returned to the original target value. As a method to return the air-fuel ratio to the original value, there may be employed any existing method, such as a method in which a weighing coefficient of a weighted means of the air-fuel ratio set to the rich side during the transition and the original target air-fuel ratio is gradually changed. When a decelerating state is detected, the target air-fuel ratio may be set to the lean side rather than the original target air-fuel ratio to attain high efficiency.

The fuel injection amount calculating part 34 calculates and sets the fuel injection amount and fuel injection timing at the start and during a normal operation of the engine according to an operation shown in FIG. 10. The operation shown in FIG. 10 is performed using an input of a crank pulse as a trigger. Although there is provided no ~~the~~ step for communication in the flowchart, the information obtained through the operation is accordingly stored in the memory in an overwriting manner and information and programs necessary for the operation are read out from the memory as needed.

Please replace the paragraph beginning on page 21, line 2 through line 14, which starts with "In the step S28" with the following rewritten paragraph:

In the step S28, the cooling water temperature, namely the engine temperature is read and a total fuel injection amount is calculated based on the cooling water temperature. For example, as the cooling water temperature is lowered, the fuel injection amount is increased. Then, the process goes to the step S31. The total fuel injection amount calculated in the step S28 or the step S30 is the amount of fuel to be injected once every cycle, namely once every two rotations

of the crankshaft, before the intake stroke. Thus, when a stroke has already been detected, the engine can be rotated properly according to the cooling water temperature, namely the engine temperature, by injecting an amount of fuel calculated based on the cooling water temperature once before each intake stroke.

Please replace the paragraph beginning on page 23, line 31 through page 24, line 4, which starts with "The ignition timing" with the following rewritten paragraph:

The ignition timing calculating part 31 calculates and sets the ignition timings at the start and during normal operation of the engine according to the operation shown in FIG. 11. The operation shown in FIG. 11 is performed using an input of a crank pulse as a trigger. Although there is provided no ~~the~~ step for communication in the flowchart, the information obtained through the operation is accordingly stored in the memory in an overwriting manner and information and programs necessary for the operation are read out from the memory as needed.

Please replace the paragraph beginning on page 26, line 17 through line 34, which starts with "In this embodiment" with the following rewritten paragraph:

In this embodiment, in which no cam sensor is used, the detection of the phase of the crankshaft and a stroke is important. In this embodiment, in which a stroke is detected based on crank pulses and an intake air pressure, the stroke detection takes at least two rotations of the crankshaft. However, it is impossible to know during which stroke the engine is stopped, namely it is impossible to know from which stroke cranking is started. Thus, in this embodiment, between the start of cranking and the completion of the stroke detection, fuel is injected at a prescribed crank angle during each rotation of the crankshaft and ignition is made at a point in the vicinity of compression top dead center during each rotation of the crankshaft using the crank pulses. After a stroke has been detected, although fuel injection which can attain a target air-fuel ratio in accordance with the throttle opening is performed once every cycle, ignition is made at about 10° in advance of compression top dead center using the crank pulses until the engine rotational speed becomes a prescribed value or higher so that a large torque can be generated.

Please replace the paragraph beginning on page 27, line 12 through line 23, which starts with "If fuel injection" with the following rewritten paragraph:

If fuel injection and ignition are performed once every cycle, namely once every two rotations of the crankshaft, before a stroke is detected, a reliable initial explosion cannot be produced when the fuel injection is performed after intake or when the ignition is made at a point other than compression top dead center. Namely, the engine may or may not be started smoothly. If fuel is injected once every rotation of the crankshaft after a stroke has been detected, fuel must continue to be injected in a motorcycle, in which the engine is used in a high rotational speed range, and the dynamic range of the injector is limited. Also, continuing ignition once every rotation of the crankshaft after a stroke has been detected is a waste of energy.

Please replace the paragraphs beginning on page 27, line 31 through page 31, line 35, which start with "FIG.13 shows" with the following rewritten paragraphs:

FIG. 13 shows the variation in crank pulses (only the numbers thereof are shown), operation mode, injection pulses, intake air pressure and engine rotational speed with time at the time when the engine is rotated from exhaust top dead center with a starter motor. In this simulation, the prescribed count-up value CNT_{N0} and CNT_{P0} of the stroke detection counters CNT_N and CNT_P are both "2". The crank pulse numbers immediately after the start of rotation are mere count values. In this embodiment, the operation mode is set to "1" when five crank pulses are detected. When the operation mode is set to "1", temporary numbers "temp. 0, temp. 1, ..." are attached to the crank pulses. When the tooth missing part is detected, the operation mode is set to "2". After the operation mode has been set to "2", the crank pulse after the tooth missing part is numbered as "6". As described before, the crank pulse number "6" should be attached to a crank pulse indicating bottom dead center after explosion. However, a stroke has not been detected yet here and the number is attached as a temporary stroke. In this embodiment, since the engine is started from exhaust top dead center, the number "6" of the crank pulse is incorrect. When the tooth missing part is detected twice in succession and an initial or a complete explosion is detected, the operation mode is set to "3".

In this embodiment, when temporary numbers are attached to the crank pulses while the operation mode is "1", a certain amount of fuel is injected by the starting asynchronous injection as described before. Also, according to the operation for setting a fuel injection amount and fuel injection timing, when a stroke has not been detected (the operation mode is "2" or "3"), half of the amount of fuel necessary to for one cycle is injected at a prescribed crank angle once every

rotation of the crankshaft, more specifically, at the time when the crank pulse “7” or “19” is generated. Also, according to the operation for setting ignition timing, when the stroke detection has not been completed (the operation mode is “2” or “3”), ignition pulses are generated so that ignition can be made at a prescribed crank angle once every rotation of the crankshaft, more specifically, at the time when the crank pulse “0” or “12” is generated (more specifically, ignition is made when the ignition pulse falls). Thus, fuel injected by the starting asynchronous injection is sucked into the combustion chamber during the intake stroke made by the first rotation of the crankshaft and makes an initial explosion by ignition at the next compression top dead center, whereby the engine starts to rotate. Thereby, the engine rotational speed becomes equal to or higher than a prescribed rotational speed for permitting stroke detection, and stroke detection is permitted. However, the rotation of the engine is still unstable and the engine has not gone into a stable idling state.

After the operation mode has been set to “3”, stroke detection based on an engine rotational speed difference ΔN and stroke detection based on an intake air pressure difference ΔP are performed at each bottom dead center. However, a stroke cannot be easily detected since the engine rotational speed and the intake air pressure are still unstable. When the engine rotational speed difference ΔN becomes the threshold value ΔN_{IN} of the engine rotational speed difference after an intake stroke or smaller at the third bottom dead center, the flag F_N for the stroke detection based on the engine rotational speed difference is set to “2” and the counter CNT_N for the stroke detection based on the engine rotational speed difference is incremented to “1” since the temporary stroke differs from the detected stroke. Then, since the engine rotational speed difference ΔN is the threshold value ΔN_{IN} of the engine rotational speed difference before the exhaust stroke or smaller again at the fourth bottom dead center, which means the temporary stroke differs from the detected stroke, the flag F_N for stroke detection based on the engine rotational speed difference is kept at “2”, and the counter CNT_N for stroke detection based on the engine rotational speed difference is incremented and counted up to “2”. At the same time, the intake air pressure difference ΔP becomes the threshold value ΔP_{EX} of the intake air pressure difference before the exhaust stroke or greater, which means the temporary stroke differs from the detected stroke, the flag F_P for the stroke detection based on the intake air pressure difference

is set to “2” and the counter CNT_P for the stroke detection based on the intake air pressure difference is incremented to “1”. As a result, the operation mode is set to “4” and the numbers of the crank pulses are shifted by a phase of 360° . Thereby, the true stroke is detected and the stroke detection is completed.

FIG. 14 shows the variation in crank pulses (the numbers thereof), the operation mode, the injection pulses, the ignition pulses, intake air pressure and the engine rotational speed with the time at the time when the engine starts to rotate from compression top dead center. Numbering, setting of the operation mode, setting of the fuel injection amount and the fuel injection timing, and setting of the ignition timing immediately after the start of the rotation are performed in the same manner as shown in FIG. 12. The crank pulse “6” after the tooth missing part after the operation mode has been set to “2” indicates bottom dead center after explosion, so that the temporary stroke coincides with the true stroke. In this simulation, the engine starts to rotate from compression top dead center, so that fuel injected by the starting asynchronous injection and fuel injected by the starting synchronous injection performed during the second rotation of the crankshaft are sucked into the combustion chamber by the intake stroke during the second rotation of the crankshaft and make an initial explosion by ignition at compression top dead center during the third rotation of the crankshaft, whereby the engine starts to rotate. Prior to this, since the engine rotational speed generated by the starter motor becomes the prescribed rotational speed for permitting stroke detection or higher, stroke detection is permitted. However, the rotation of the engine is still unstable and the engine has not gone into a stable idling state.

Also in this simulation, after the operation mode has been set to “3”, stroke detection based on an engine rotational speed difference ΔN and stroke detection based on an intake air pressure difference ΔP are performed at each bottom dead center. In this simulation, the engine rotational speed difference ΔN becomes the threshold value ΔN_{EX} of the engine rotational speed difference before the exhaust stroke or greater at the first bottom dead center after the operation mode has been set to “3”, which means the temporary stroke coincides with the detected stroke. Thus, the flag F_N for stroke detection based on the engine rotational speed difference is set to “1” and the counter CNT_N for stroke detection based on the engine rotational speed difference is incremented to “1”. Then, at the second bottom dead center, the engine rotational speed

difference ΔN is the threshold value ΔN_{IN} of the engine rotational speed difference after the intake stroke or smaller, which means that the temporary stroke coincides with the detected stroke. Thus, the flag F_N for stroke detection based on the engine rotational speed difference is kept at “1” and the counter CNT_N for stroke detection based on the engine rotational speed difference is incremented and counted up to “2”. Then, since the counter CNT_N for stroke detection based on the engine rotational speed difference counts up with the flag F_N for stroke detection based on engine rotational speed difference at “1”, the temporary stroke detection is completed.

Thereafter, since the engine rotational speed difference ΔN is the threshold value Δ_{EX} of the engine rotational speed difference before the exhaust stroke or greater at the next bottom dead center, which means the temporary stroke coincides with the detected stroke, the flag F_N for stroke detection based on the engine rotational speed difference is kept at “1” and the counter CNT_N for stroke detection based on engine rotational speed difference is incremented to “3”. At the next bottom dead center, the engine rotational speed difference ΔN is the threshold value ΔN_{IN} of the engine rotational speed difference after the intake stroke or smaller, which means that the temporary stroke coincides with the detected stroke, so that the flag F_N for stroke detection based on the engine rotational speed difference is kept at “1” and the counter CNT_N for stroke detection based on the engine rotational speed difference is incremented to “4”. At the same time, the intake air pressure difference ΔP is the threshold value ΔP_{IN} of the intake air pressure difference after the intake stroke or smaller at the bottom dead center, which means that the temporary stroke coincides with the detected stroke, the flag F_P for the stroke detection based on the intake air pressure difference is set to “1”, and the counter CNT_P for the stroke detection based on the intake air pressure difference is incremented to “1”. As a result of this, the operation mode is set to “4” and the numbers attached to the crank pulses are left unchanged as the true strokes, and the stroke detection is completed.

Please delete the heading “INDUSTRIAL APPLICABILITY” on page 32, line 11.